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# **Active Conceptual Modeling of Learning Workshop**

**10–12 May 2006**

L. Y. Wong

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# INTRODUCTION

## GOAL

The Active Conceptual Modeling of Learning (ACM-L) Workshop convened to accomplish the following goals:

- Introduce the Science and Technology (S&T) challenge
- Provide a forum for the exchange of ideas and research results of the proposed research and the impact in the Department of Defense (DoD) and commercial applications
- Identify a research and development (R&D) agenda for a technology development investigation

The ACM-L effort aims to develop ACM-L technology for next-generation learning-base system development. The effort focuses on enhancing our fundamental understanding of how to model continual learning from past experiences, and how to capture knowledge from transitions between system states. This understanding will enable us to provide traceable lessons learned to improve current situations, adapt to new situations, and potentially predict future actions. The goal is to provide a theoretical framework for the ACM-L. This framework is based on the Entity-Relationship (ER) approach and the human memory paradigm for developing a learning base to support complex applications such as homeland security; global situation monitoring; command, control, communication, computers, intelligence, surveillance, and reconnaissance (C4ISR); and cognitive capability development.

## DESCRIPTION

The workshop was attended by invited researchers/participants and SPAWAR Systems Center San Diego (SSC San Diego) employees. All workshop sessions were unclassified. The agenda for the workshop, keynote addresses, and position paper abstracts are provided in Appendices A, B, and C.

## S&T CHALLENGE ADDRESSED

Increasing changes in the real world demand a shift in conceptualization and a new way of viewing reality. We envision the future information environment as one that provides closer communication between the user, systems, and software modules. Therefore, we must understand and master the role of information management that intersects the real world and the software universe. Shifting from the passive to an active paradigm is necessary to model the real world in a manner that enables continual learning from past and present information to support the adaptive C4ISR process.

## C4ISR Challenge

C4ISR is fundamentally a process of continuous adaptation to a changing situation described by the Observation-Oriented-Decision-Action (OODA) cycle or loop. A successful C4ISR system must adapt to rapidly changing situations. It must seek and assess information, learning and adjusting its desire for continual survival. Decision-makers need to understand operational assumptions about information changes and compare current operations to expectations. They must do this in order to understand what significant surprises are occurring and the relationships between temporal events, spatial events, intelligence, classifications, and forensics. Recognizing change and quickly relating the impact of that change to the current situation is essential. Continuous awareness and watchful monitoring of world situations are necessary.

Legacy stovepipe data systems dominate DoD C4ISR systems, and because they use the static model, current information systems can only reflect the most recent stored data. Limitations in modeling and processing changes between system states have led to inadequate applications support for C4ISR missions.

### **Information Technology Limitations**

As the cornerstone for our nation's technology infrastructures, information technology has made a tremendous impact on our society in recent decades. Central to this cornerstone is the process of conceptual modeling. With the advent of information technology, system developers can now use sophisticated techniques to model the world by mapping real-world scenarios onto information systems and applications. However, today's databases and knowledge bases only reflect the static characteristics of the intended Universe of Discourse (UoD). These characteristics are captured by the conceptual model as distinct snapshots. The information system, which provides "almost recent" information, does not support applications that require historical information, nor does it provide information for projecting the future based on past experience and lessons learned. When the relationships between snapshots are unavailable, simulating "what-if" scenarios is difficult. The notion of time is not directly supported because temporal relationships among entity behaviors cannot be fully modeled. Therefore, data changes, schema changes, and historical information cannot be supported or managed. A wide spectrum of situations that result from different degrees of importance of the relationships from different perspectives cannot be represented. The wide use and varied forms of information systems demonstrate the dynamic contributions of information technology. However, support for complex applications (e.g., adaptive C4ISR, homeland security, global information sharing, law enforcement, forensic investigation, peacekeeping, etc.) demands a new paradigm for modeling the relationships among the real world, the software universe, and technology development from an integrated perspective.

## **APPROACH: ACTIVE CONCEPTUAL MODELING OF LEARNING**

An active paradigm was used to investigate the proposed S&T. To achieve adaptive C4ISR, learning from past experience is essential. Learning is a continuous process by which relatively permanent behavioral changes occur, potentially as a result of an experience. The basic process of learning includes the following:

- Input: Observe and select information from the domains in our environment
- Observation/Interpretation: Analyze and understand the selected information and make connections between past, present, and anticipated information from different contexts in order to identify central features
- Integration and Synthesis: Assimilate new information based on collective experiences to internalize and structure the data and draw inferences and/or conclusions
- Application: Choose and execute actions, thoughts, and applications based on what is learned

While perception is associated with the five senses (e.g., seeing, hearing, tasting, smelling, and touching), experience is a broader category. It is a kind of knowledge that includes inference and reasoning about the totality of past events through direct or indirect participation as an individual or group. Learning, which is reflected by discrete changes between states of knowledge, creates meaning from experience. Experience, which is the basis of learning, comprises knowledge or skills in or observation of some event gained through direct or indirect involvement in or exposure to people, environment, and/or events.

Lessons learned are a powerful method of sharing ideas for improving the current situation. A "lesson learned" is defined as "a good work practice or innovative approach that is captured and shared to promote repeat application, or an adverse work practice or experience that is captured and shared to avoid recurrence" [1]. Lessons learned represent knowledge generated by reflecting on experience that can avoid past mishaps, share observations, and improve future actions. While learning is an ongoing process that transfers knowledge from one state to another, a lesson learned summarizes knowledge at a point in time. To describe an experience is to model the past situation/event and associated knowledge from a different perspective. This historical perspective allows system developers to describe a lesson learned from the interaction of episodic and semantic memories describing general knowledge about the situation or domain in terms of the following:

- Topic: What was it about?
- Time/Space: When and where did it happen?
- Scenario: How did it happen?
- Players: Who were involved and what roles did they play?
- Cause/Effect: What may have caused it to happen and what did it tell us?

Episodic memory is the explicit memory of events. It is considered a "one-shot" learning mechanism. Semantic memory, on the other hand, considers multiple exposures to each referent. The semantic representation is updated on each exposure. Episodic memories, which have some similarities to written stories, can be viewed as a mental map that ties items together in semantic memory. The combined memories help us to recognize information coming through our five senses that can be interpreted and valued to form judgments through our thinking process. The plan was to investigate the relationships between episodic and semantic memory.

Complementary to machine learning, which attempts to develop systems to accumulate knowledge based on past experience and analytical observations, this effort focused on relationships between past knowledge/data and current knowledge/data from different perspectives. We proposed a framework for learning based on active conceptual modeling.

## **ACTIVE CONCEPTUAL MODELING**

Active Conceptual Modeling [2], [3], [4] is a continual process that describes all aspects of a domain, its activities, and changes under different perspectives based on multi-perspective knowledge and human cognition. For any given time, the model is viewed as a multi-level (e.g., personal, organizational, global)/ multi-perspective (e.g., DoD services), high-level abstraction of reality. The original goal of a database was to model some aspects of the real world of interest. The purpose of traditional data modeling is to help us better understand a specific real-world domain and enhance communication among ourselves. With the advent of the Internet, conceptual modeling is shifting to the proposed active paradigm. Information management, which has a new meaning in the context of the Internet, calls for new modeling techniques.

Conventional conceptual modeling for database design is a simple case of active modeling. The active conceptual model will provide the necessary control and traceability for the domain by linking snapshots to form a dynamic and moving picture of the evolving world. This single dynamic model will integrate temporal and special entities, time-varying relationships, temporal events, dynamic classification of entities, and uncertainty. The model will help us understand relationships among state changes and to continually learn and make inferences by providing traceable lessons learned from past experiences, which could be used to predict future actions. The active model would therefore subsume the current databases and knowledge bases.

The active model can only be realized through integration technology (e.g., artificial intelligence (AI), software engineering, information technology, cognitive science, arts and sciences, philosophy, etc.) and a combination of modeling techniques. The state-of-the-art in conceptual modeling can be used as the starting point. A framework of modeling approaches (e.g., ER [5], OO, Extensible Markup Language [XML], frame-based conceptual structures, ontology, Petrinet, etc.) must be established. Modeling techniques must be combined to visually model different characteristics of the world (e.g., temporal, multimedia, spatial, cognitive, philosophical, historical, etc.).

## WORKSHOP FOCUS

The ACM-L effort focused on designing, developing, and demonstrating a *learning base* that will represent and monitor situations with lessons learned from previous experiences and notify warnings to support a large class of applications. To accomplish ACM-L, investigation of the following basic and exploratory research areas would be required:

- Integrating time, space, and perspective in ER/conceptual model
- Mathematical framework for conceptual models
- Mapping of constructs among conceptual models
- Multi-level conceptual modeling
- Multi-perspective conceptual modeling
- Aspects of conceptual modeling
- Modeling of information and event changes
- Dynamic reserve modeling
- Executable conceptual model
- ER and Knowledge Representation
- Multi-media information modeling
- Information extraction, discovery, and summarization
- Continuous knowledge acquisition
- Learning from experience
- Transfer learning among domains
- Combined episodic and semantic memories

While the ACM-L effort would like to explore different approaches for continuous modeling, this workshop focused on entity and relationship, which are the most fundamental concepts for modeling the real world. Using a new perspective, workshop participants discussed theoretical extensions to the ER approach, which has significantly contributed to database/information modeling, software engineering, and knowledge management. The executable conceptual model is an essential concept that needs further exploration as a basis for active information/learning-base system implementation.

## BREAK-OUT SESSIONS

Working sessions took place after the position paper presentations. Workshop participants were divided into two technical groups and one application group. The working sessions identified key relevant areas with research issues, available references, and potential R&D accomplishments. The information was intended for the development of a roadmap for future R&D efforts in ACM-L.



## Technical Sessions

The two technical sessions focused on the following areas and issues:

### 1. Time and Events

**Issues:** Semantics of connections between time and events; characterization and classification of events; complexity of events with issues of composition, decomposition, splitting, merging and overlapping, etc.; temporal logic and granularity; the meaning of time between state and event, initiation, detection, processing, timeframe for decision-making, and time in the future; and integrating time in conceptual modeling

**Short Term:** Temporal concepts and terminology for active conceptual modeling

**Medium Term:** Time-related event processing system

**Long Term:** Integrating temporal in active conceptual model

### 2. Continuous Changes

**Issues:** Representing snapshots and time-varying attribute values as a means for modeling changes, computing delta between snapshots with different types of data, preserving time-varying data reflecting their multi-level and multi-perspective environment, ecological processes and operations, and methods for detecting changes in multimedia data

**Short Term:** Recognizing changes in structured and semi-structured data

**Medium Term:** Methods for detecting changes in multimedia data

### 3. Understanding and Processing of “Stories”

**Issues:** Vagueness, uncertainty, inconsistency. What makes a set of events a “story”? Research in AI has dealt with unstructured data, but only with a few cases involving a few parameters. The approaches were informal and the interpretations often were not unique. Data have many forms, and establishing commonality is difficult. “Markers” have been used to extract and summarize information, and semantics of “markers” need to be defined more clearly. Conceptually processing “stories” is feasible, but the scalability issues of generating and processing “stories” may be difficult. Other issues are the verification of “stories,” provenance issues that include semantics of provenance and automation, and acquisition of provenance.

**Short Term:** Conceptually modeling “stories” in ER framework

**Medium Term:** Generating and processing “stories”

**Long Term:** Assessment and evaluation of impact in decision-making

### 4. Events and Triggers

**Issues:** Representing workflow on top of the events, creating a trigger view on top of conceptual view, rich triggers with spatial and temporal processes, and integrating flow processes with policies and regulations

**Short Term:** Diagrammatic techniques for representing workflow and conceptual views

**Medium Term:** Diagrammatic representation of workflow over events, triggers with spatial and temporal features

**Long Term:** Flow processes with policies and regulations with entities

## 5. Learning and Monitoring

**Issues:** Reference on learning includes knowledge discovery, inference, machine learning, case-based and analogical reasoning, and causality; generalization from instances to schema and schema evolution based on past experience or new data collected, the detection of “anomalous events”; whether new data are consistent with known “signature” concepts or rules; limitations and constraints need to be considered when an action taken depends on the time window and number of outliers; and the use of “sliding windows” for continuous processing.

**Short Term:** Realizing rules and knowledge learning from instances

**Medium Term:** Detecting some types of anomalous behavior

**Long Term:** Continuous learning and knowledge discovery

## 6. Schema Evolution and Version Management

**Issues:** Preserving historical changes with schema evolution, processing data under past environment with rules and policies applicable at the time in the past, tracing the sources of the changes in the past and forecasting future trends, representing incremental and discrete changes with versions, and version migration and management.

**Short Term:** Linking ER schema changes to XML

**Medium Term:** Developing tools for data migration

**Long Term:** Providing schema evolution in ER conceptual model

## 7. Executable Active Conceptual Model and Database Management System

**Issues:** Creating executable conceptual model; supporting changes in conceptual model; generating and maintaining incremental executable versions; ensuring information and data semantic integrity; managing persistent storage for active data; providing transparency and traceability between users, applications, conceptual schema, and stored data.

**Short Term:** Concepts and basic building blocks for executable conceptual model

**Medium Term:** General architecture for ER database management system

**Long Term:** ER database management system for storing and accessing active data.

## Application Session

In their discussion, participants in the application break-out working session focused on the operation requirements of the following scenario:

- Continuous briefing display must accommodate surprise in the sense that a new type of event has occurred
- Look at previous instances and use them to compare to what we are seeing this time
  - ◆ Previous operations
  - ◆ Sea stories
  - ◆ Branches representing hypotheses
  - ◆ Morph into a new plan

- Model 23 scenarios
  - ◆ Pull information in to support the scenarios
  - ◆ Modify to match real world and capture the reasons for change and the temporal aspects of when they changed
- What is different if we look at things from small components versus one monolithic system?
- Liberating instances from the tyranny of classes; bottom up/dynamic classification
  - ◆ Add new classes (e.g., insurgents)
  - ◆ Reasons can be based on data mining or analysis what if, uncertainty
- Tagging is part of the Standard Operating Procedures (SOPs) and the database. Tag information as invariant, fuzzy, tied to some rule; what are the ways that knowledge can legitimately change?
- Focus on unclassified information initially from Asia-Pacific Area Network (APAN) and Internet. Use basic tool set (e.g., Microsoft® Office 2003 Professional or 2007 Professional and Google™ Earth for map imagining, etc.)
- Design events that “trigger” alerts
- Build a database that compiles some past history, sea stories, and Web pages that can be accessed, assessed, visualized; and that take a course of action

## **FINDINGS**

Among a broad spectrum of issues discussed, participants identified key technical areas and stressed the importance of developing an S&T team to address them. The following categories were based on results from the position papers and break-out working session.

### **1. Integrating Time, Space, and Perspective in Conceptual Model**

The ACM-L effort needs to investigate alternative approaches for representation of snapshots (which include the time and space dimensions) and computation of the difference between snapshots to derive significant changes. The ACM-L research community can then provide a theoretical basis for this conceptual model that includes multi-level and multi-perspective representation of information. They will build a historical view of information on semantics of information provenance in terms of “when,” “where,” “how,” “who,” and “why,” and their relationships. Having accomplished this goal, they can then create the background knowledge for interpreting and understanding information in a holistic manner.

These issues are addressed in the following position papers:

- Understanding the Semantics of Provenance to Support Active Conceptual Modeling
- A Rule-Based Approach to Entity-Relationship Modeling
- Modeling and Integration of Active Spatial Data for Future GIS-based Applications

### **2. Management of Continuous Changes and Learning**

Continuous situation cognizance and monitoring are the key prerequisites for systems supporting adaptive C4ISR. The iterative process of the OODA loop, which provides situation alertness, is also a learning process. The speed of the process is important for an effective system. The ACM-L research community needs to investigate active capability with context-aware adaptation and proactive impact in order to detect changes and react to the evolution of the environment. which results from changes in the values of various (possibly correlated) attributes. Hypothetical “what-if” queries will be researched to provide a foundation for testing, learning, and modifying the systems.

Key issues to be addressed include the following:

- Relationship of time, events, and triggers in evolving systems
- Understanding, representation, and processing of “stories” composed of a set of timed events
- Relationship of learning and monitoring of events

These Issues are addressed in the following position papers:

- Approaches for Active Conceptual Modeling of Learning
- Harness Dynamic Human Data and Knowledge: A Grand Research Challenge
- Superimposed Tools for Active Arrangement and Elaboration of Resources to Support and Document Learning

### **3. Behaviors of Evolving Systems—Model Evolution, Patterns, Interpretation, Uncertainty, Fusion**

The ACM-L effort needs to investigate the behaviors of evolving systems, which include model evolution in terms of addition/deletion of entities, attributes, relationships, and values of the instances. To recognize patterns without many false alarms, accurate methods for recognizing patterns are needed. Matches of complex patterns will rarely be perfect. Good methods would help find a large percentage of the relevant instances with a small fraction of irrelevant matches. The ACM-L effort will explore filtering and fusion techniques for recognizing patterns and anomalies in large volumes of uncertain information.

Key issues to be addressed include the following:

- Schema evolution and version management in ER conceptual model
- Dynamic reverse modeling
- Complex event processing

These issues are addressed in the following position papers:

- The Event Construction in Active Information Systems
- Adaptive and Context-Aware Reconciliation of Reactive and Pro-Active Behavior in Evolving Systems
- Schema Changes of Historical Information In Conceptual Models of Learning

### **4. Executable Conceptual Model**

The ACM-L effort needs to investigate execution of the active conceptual model, which supports information change management; generating and maintaining incremental executable versions; ensuring information semantic integrity; managing persistent storage for active data; and providing transparency and traceability between users, applications, conceptual schema, and stored data. The executable model will serve as a basis for user interface development.

These issues are addressed in the following position papers:

- An Active XML Data Model
- Formal Foundations of Conceptual Modeling for Learning from Surprises

# CONCLUSION

## RESEARCH

State-of-the-art conceptual modeling is a simple case of the proposed active conceptual modeling. The fundamental innovation of ACM-L is to revolutionize how database systems are built. If the ACM-L effort succeeds, it will change the way database systems are constructed by pushing state-of-the-art conceptual modeling considerably beyond past achievements in database technologies. The initial assessment was that ACM-L could provide a theoretical conceptual foundation for developing the next generation of active information/learning-base systems. This active system will provide a new info-forensics capability to first backtrack the database to the occurrence of a specific event and then establish an outlook progression of the incident to identify possible oversight of missing faces. Through ACM-L, ongoing lessons learned could be achieved, which may provide insights into the future. The active model will provide a closer UoD conceptualization for implementation as an information system/architecture, which will enable continuous learning of the world and provide a constant challenge for technical inventions.

## APPLICATION

ACM-L results could help satisfy the following operational requirements under consideration at U.S. Pacific Command (USPACOM):

- Develop a real-time command that anticipates operational needs, creates opportunities, and operates within the competition's decision-cycle and predicts potential problems. "Real time" means making necessary information available to the people and systems that need it, when they need it, and in a way in which they can act effectively on that information.
- Execute complex event processing solutions that sift meaning in real time.
- Unearth important combinations and patterns of events that span multiple, disparate systems.

The workshop was well attended by SSC San Diego personnel, external participants from Air Force Rome Labs, the National Institute of Standards and Technology, SRI, Inc., and SPAWAR Headquarters, etc. The intent of the workshop was to cover as much of the topic as possible. As gauged by the level of discussion, the enthusiasm of the participants, and feedback, the workshop was very successful, and the need to continue work in this area is important. A wide spectrum of research issues were identified and recommendations were made to address these issues.

## NEXT STEPS

The participants agreed that the conceptual modeling community has developed sound theory and practices to help analysts capture more semantics. However, more dynamic aspects in the conceptual models need to be captured. Some concepts already exist, and static model theory is well developed; what remains is to investigate them in continuous active modeling and link them to learning. Predicting system evolution will enable risk assessment and adaptive decision-making.

The participants agreed that no single research group can achieve the ACM-L vision. They identified the following immediate actions that would assist in addressing the issues discussed:

- Conduct surveys of existing work in each area and develop a comprehensive reference resource and bibliography of work in relevant areas. Establish a collaborative Web-based repository at Louisiana State University (LSU) to which this research community will contribute and update information.
- Provide more workshop and working sessions on this topic. A special session has been suggested at the forthcoming FR06 conference. An annual workshop would be valuable in motivating the group.
- Provide cross-fertilization among valuable related fields, such as ontology, knowledge representation, knowledge management, network theory, simulation, visualization, and information science.
- Critically analyze existing models. Incorporate constructs for developing and evolving a focused ACM-L collective proposal.
- Develop and maintain a repository of application cases that the research community can use for testing ideas, proposals, and prototype systems.

## REFERENCES

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- [3] Peter P. Chen and Leah Y. Wong. 2005. "A Proposed Preliminary Framework for Conceptual Modeling of Learning from Surprises," International Conference on Artificial Intelligence, pp. 27–30 (June), Las Vegas, NV.
- [4] Leah Y. Wong. 1998. "An Active Paradigm for Information Management." SSC San Diego Technical Report 1780, San Diego, CA.
- [5] Peter P. Chen. 1976. "The Entity-Relationship Model: Toward a Unified View of Data," *ACM Transactions on Database Systems*, vol. 1, issue 1, ACM Press, New York, NY.





## APPENDIX A

### WORKSHOP AGENDA

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#### Active Conceptual Modeling of Learning Workshop WEDNESDAY–FRIDAY, 10–12 MAY 2006 Conference Center, A-33 AGENDA

#### WEDNESDAY, 10 MAY 2006 - TECHNICAL SESSION – 1

0730-0815	Registration, Bldg 27 (Security)  Proceed to Bldg 33, Conference Center, 4 <sup>th</sup> Floor	<b>JAN STULL</b> SSC San Diego
0830-0835	Welcome, Conference Center	<b>CAPT FRANK UNETIC</b> Commanding Officer, SSC San Diego
0835-0910	Introduction of Speakers/Admin Remarks SSC San Diego Overview	<b>TOM LAPUZZA</b> SSC San Diego
0910–0925	SSC San Diego Academic Outreach	<b>DR. ERIC HENDRICKS</b> SSC San Diego
0925–1000	Introduction of Workshop	<b>LEAH WONG</b> SSC San Diego
1000–1030	<b>Break</b>	
1030	Introductions	<b>DR. LORRAINE DUFFY</b> SSC San Diego
1030-1130	Conceptual Modeling of Learning From Surprises-Wrapping Your Arms Around Chaos	<b>DR. JENS JENSEN</b> USPACOM
1130	Introductions	<b>LEAH WONG</b>
1130–1215	Keynote Address “Active Conceptual Modeling: The New Frontier in R&D”	<b>DR. PETER CHEN</b> Louisiana State University

1215–1315	<b>Lunch, Cloud Room Veranda</b>	
1315–1345	Understanding the Semantics of Provenance to Support Active Conceptual Modeling	<b>DR. SUDHA RAM</b> University of Arizona
1345–1415	The Event Construct in Active Information Systems	<b>DR. SALVATORE MARCH</b> Vanderbilt University
1415–1445	Formal Foundations of Conceptual Modeling for Learning From Surprises	<b>DR. STEVE LIDDLE</b> Brigham Young University
1445–1500	<b>Break</b>	
1500–1530	An Active XML Data Model	<b>DR. TOK WANG LING</b> National University of Singapore
1530–1600	Schema Changes and Historical Information in Conceptual Models of Learning	<b>DOUG LANGE</b> SSC San Diego
1600–1630	A Rule-Based Approach to Entity-Relationship Modeling	<b>DR. IL-YEOL SONG</b> Drexel University
1630	End of first day technical session	
1645–1800	Light refreshments in Conference Center	

## **THURSDAY, MAY 11, 2006 – TECHNICAL SESSION – 2**

0830–0900	Database Technology Needs for Advanced Reasoning and Learning	<b>TED SENATOR</b> DARPA/IPTO
0900–0930	Approaches for Active Conceptual Modeling of Learning	<b>DR. HANNU KANGASSALO</b> University of Tampere, Finland
0930–1000	Harness Dynamic Human Data and Knowledge: A Grand Research Challenge	<b>DR. T.C. TING</b> University of Connecticut
1000–1030	Adaptive and Context-Aware Reconciliation of Reactive and Pro-Active Behavior in Evolving Systems	<b>DR. PETER SCHEUERMANN</b> Northwestern University
1030–1045	<b>Break</b>	

- |           |   |  |
|-----------|---|--|
| 1045–1115 | Modeling and Integration of Active Spatial Data for Future GIS-Based Applications                       | <b>DR. SHAMKANT NAVATHE</b><br>Georgia Institute of Technology   |
| 1115–1145 | Superimposed Tools for Active Arrangement and Elaboration of Resources to Support and Document Learning | <b>DR. LOIS DELCAMBRE</b><br>Portland State University   |
| 1145–1245 | <b>Lunch on the Cloud Room Veranda</b>  |  |
| 1245–1330 | <b>Panel Discussion</b>   | <b>DR. JOHN SALASIN</b><br>NIST<br><b>DR. JAMES LANG</b><br>COL, USAF, RET<br><b>WORKING SESSION</b><br><b>MODERATOR (TBD)</b> |
| 1330–1500 | <b>Break-out Working Sessions</b> (locations to be announced)   |  |
| 1500–1515 | <b>Break</b>  |  |
| 1515–1545 | Report From Working Sessions  |  |
| 1545–1600 | <b>Wrap-up</b><br>- Acknowledgement<br>- Kick-off for Roadmap Discussion                                | <b>LEAH WONG</b><br><b>DR. PETER CHEN</b>  |
| 1600      | <b>End of workshop technical session</b>  |  |

**FRIDAY, MAY 12, 2006 - PLENARY SESSION (Cloud Room)**

*Breakfast on your own, Coffee will be served; however, Cafeteria is closed*

- |           |                              |   |
|-----------|------------------------------|---|
| 0900–0920 | The Needs of the Warfighters | <b>VADM LYLE BIEN, USN,</b><br><b>RET</b> |
| 0920–1200 | Roadmap Discussion           |   |
| 1200      | <b>End of Workshop</b>       |   |

Note: (1) The names listed are the names of the presenters of the papers  
 (2) The following paper will not be presented: "Challenges to Conceptual Modeling," Bernhard Thalheim of Kiel University, Germany



## **APPENDIX B**

### **CONCEPTUAL MODELING OF LEARNING FROM SURPRISES WRAPPING YOUR ARMS AROUND CHAOS**

Jens A. Jensen, PhD

Joint Operation Planning and Execution System (JOPES) Functional Manager

Operations Directorate

United States Pacific Command

Camp H. M. Smith, HI 96861-4013

USA

#### **Abstract**

*The world is a chaotic place. Monitoring world events and making sense of them is more art than science. Gathering data, comparing to models, providing analysis and presenting to decision-makers are key elements for study. Consider the longstanding efforts to model the global climate and weather, yet, we continue to be surprised by climatic events on a local scale. Even after years of study, we remain challenged to provide adequate models to predict the future with regards to climate. The focus of this paper is to support the preliminary thesis for conceptual modeling of learning from surprises. The attack on the World Trade Center on September 11, 2001, the Tsunami disaster in the Indian Ocean Basin which occurred in Indonesia and other countries in 2004, and the large mudslide that occurred in the Philippines in 2006 made the whole world realize that we need to analyze past surprises and, possibly, predict future surprises. The much anticipated Pandemic Influenza threat is worthy of consideration as an example. While we might anticipate its occurrence, it is almost certain that the actual event will be a surprise and the consequences will be chaotic on a global scale.*

#### **Keywords**

chaos, conceptual modeling, learning, surprises, system modeling, database, knowledge base, complex event processing (CEP), event triggers

#### **1.0 Introduction**

Surprise is more the rule than the exception. For example, the United States has never executed a deliberate plan. Every military operation has required planning from scratch or at best significant modification to an existing contingency plan through crisis action planning procedures. Little understanding exists with regard to world events that ultimately lead to some culminating event. The problem is that many of these events surprise us and due to a rapid turnover of personnel, leads to surprise and a chaotic response initially.

Experience demonstrates to us that surprise is the normal course of events. Resources are limited and no models exist to monitor human interaction on national, regional and global scales. The problem has not only been plucking the meaningful events from the unimportant ones but also finding the often seemingly unrelated patterns between them, and doing so before it's too late to make a difference. We are capable of collecting huge amounts of data and do. Gleaning the

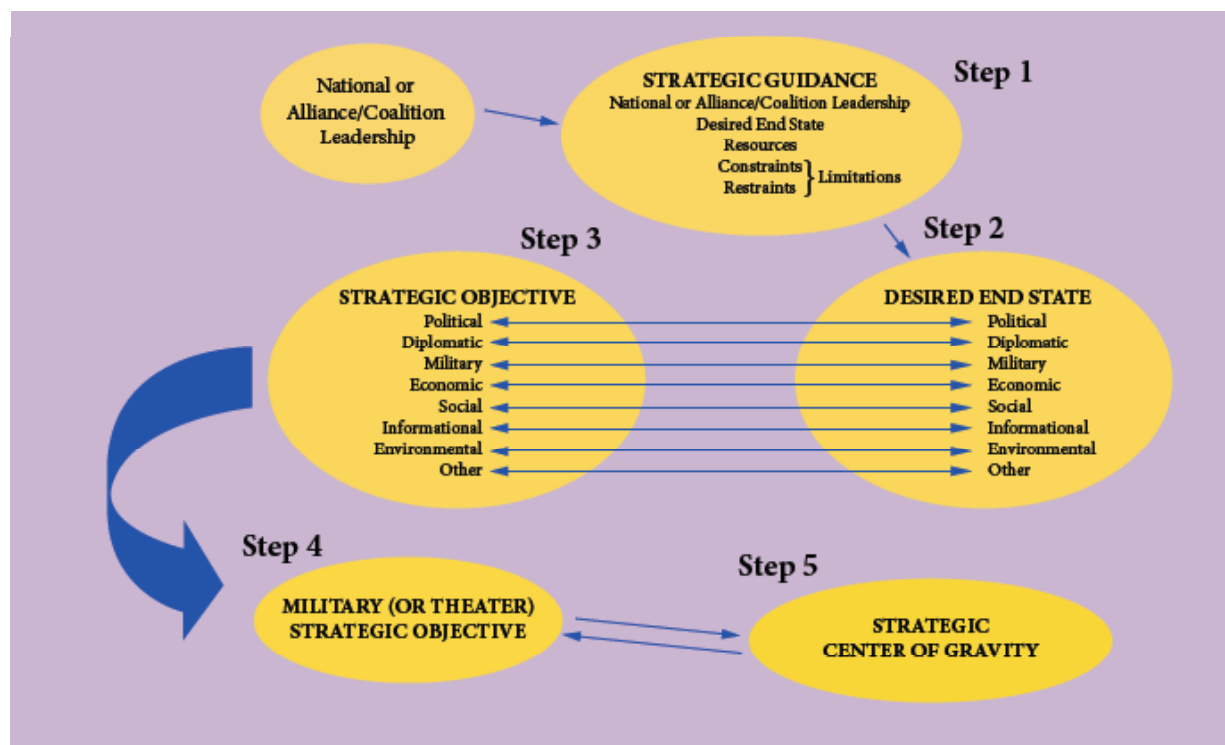
importance of what we have gathered is the difficult part. Complex Event Processing (CEP) promises to assist in capitalizing on the rich data and information hidden away in our data/information warehouses. The science supporting CEP is the ability to create high-level “operational” events from numerous low-level system events. CEP events are created by filtering real-time data and infusing it with defining detail such as dependencies or causal relationships discovered by correlating intermediate event objects for analysis. Successful matches to comparative rules, which can include relationship and temporal assessment, can invoke actions such as an alert or an e-mail to a decision-maker, or they can spawn an entirely new event. The questions proposed by Peter Chen and Leah Wong are typical of the questions that must be asked in defining the requirements for this project as listed in this paper.

- How do we analyze the surprise scenarios?
- What information do we need to analyze the surprise situations?
- What have we learned from the surprises?
- How can we handle surprises in current and future world situations?

My effort is to provide to operational context for the effort.

## 2.0 Problem

From a political, military, economic, social, diplomatic, infrastructure, information, geologic, and climatic perspective the Earth is an extremely complex unit. Mathematical methods for predicting and measuring events and effects must be used with care. Using various metrics to assess essentially unquantifiable aspects of worlds events attempt to make what is more art, science.



Source: “Effects-Based Operations: A Critique”, Milan N. Vego, *Joint Force Quarterly*, Issue 41, 2nd Quarter 2006.

The above figure provides a picture of the types of topics that are considered during the military decision-making process. Working backwards from operations to identify through operational forensics the patterns and events that would have triggered earlier recognition and more timely evaluation of a building crisis.

### **3.0 Presentation Objective**

The presentation will provide background of real events in order to provide background on the military decision-making process. The basic process of learning includes the following [1]:

- (1) *Input*: observe and select information from the domains in our environment
- (2) *Observation/Interpretation*: analyze and understand the selected information and make connections between past, present, and anticipated information from different contexts in order to identify central features
- (3) *Integration and Synthesis*: assimilate new information based on our experiences or others' experiences in order to internalize and structure the information and draw inferences and/or conclusions
- (4) *Application*: choose and execute actions, thoughts, and applications based on what is learned

I would expect that in addition to the above that appropriate sources of data and information are required, case templates, rules and filters and transaction histories will also be required. Analysts will monitor for flagged triggers and conditions and adapt the rules according to operational needs and changing operational conditions. Some event processing language is required to model "complex event" objects based on low-level system events and to define the rules that trigger alerts and actions. Lessons learned, battle logs, interviews, and other after action review documents will aid in defining and updating the proposed system.

### **4.0 Conclusion**

High turnover rates amongst military decision-makers, the infrequency of events, the often dissimilarities in events, and other complications make a conceptual model for learning from surprises an operational imperative. The world is a complex environment. A solution for this complex environment will have to sift through streams of event data from distributed systems looking for combinations of events or patterns with operational significance and triggering actions in response. The attached presentation provides an overview of the Tsunami Relief Effort in early 2005.

### **References**

[1] Chen, Peter P. and Leah Wong 2005. "A Proposed Preliminary Framework for Conceptual Modeling of Learning from Surprises," *Proceedings of the 2005 International Conference on Artificial Intelligence*, 27–30 June, Las Vegas, NV

### **Biography**

#### **Jens A. Jensen**

The Deputy, Future Operations Division, Operations Directorate, Headquarters, United States Pacific Command, Honolulu, Hawaii. He completed 24 years as an officer in the United States Navy. He has nearly 20 years experience in contingency planning, crisis action planning and execution of military operations. He has earned academic degrees in Earth Science, Systems Technology, Military Science and Crisis Management.

# Active Conceptual Modeling: A New Frontier for Research and Development

Peter P. Chen  
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**The research of the author was supported in part by National Science Foundation grant: ITR-IIS-0326387 and AFOSR grant: FA9550-05-1-0454.**

## Abstract

The conventional/traditional conceptual modeling concentrates on modeling the “static” views (i.e., the snapshots) of the world. Active conceptual modeling is a continual process of describing all aspects of the open world, its activities, and its changes under different perspectives, based on our knowledge and understanding. For any given time, the model can be viewed as a multilevel and multi-perspective high-level abstraction of reality.

The active conceptual model will provide the necessary needs of control and traceability for the evolving and changing world state. It will help understand relationships among changes, which may have significance to current world state (e.g., terrorist training could have been changed since the 9-11 attack). The active model allows for continual learning and provides traceable lessons learned from past experiences, including surprises, which may be potentially useful for predicting future actions.

After three decades of efforts of many researchers and practitioners, the conventional (static) conceptual modeling methodologies and techniques based on the Entity-Relationship (ER) model and its extensions [1] have been practiced daily by hundreds of thousands of professionals and developers all over the world. Now, the time is right to start a major research and development effort in active conceptual modeling. However, many challenging research problems need good solutions:

- Time/Space: How can we model the “time” and “space”?
- Scenario: How can we describe a scenario?
- Players: Who were involved and what roles did they play?
- Cause/Effect: What is the best way to describe the cause-effect relationship?
- Event/Activity: Do we need different symbols (icons) to represent event and activity?  
How can we relate events with activities?

These are some of the tough questions that need clean solutions so that the active conceptual modeling can be moved from the research stage to the development stage, and then to the practice stage. We hope the R&D community will be able to develop and perfect the active conceptual modeling methodologies and techniques quickly so that we can realize the benefits [2] of the active conceptual modeling in the not too distant future.

## References

- [1] Conceptual Modeling (ER) Conferences Proceedings, <http://www.conceptualmodeling.org> .
- [2] Chen, Peter P. and Leah Wong 2005. “A Proposed Preliminary Framework for Conceptual Modeling of Learning from Surprises,” *Proceedings of the 2005 International Conference on Artificial Intelligence*, 27–30 June, Las Vegas, NV.



## **Dr. Peter Chen (Keynote Speaker)**

**Dr. Peter Chen** is Distinguished Chair Professor at Louisiana State University (LSU). After receiving his PhD degree from Harvard, he served on the faculty of the Massachusetts Institute of Technology and the University of California Los Angeles before assuming his current position at LSU in 1983. He has also served as visiting professor at Harvard and MIT.

He is internationally known for his original work of the Entity-Relationship (**ER**) **Model**, the foundation of many systems analysis and design methodologies and frameworks such as **IBM's AD/Cycle**, computer-aided software engineering (**CASE**) tools, and repository systems including **IBM's Repository Manager/MVS**. The ER model was adopted as the **ANSI standards** in Information Resource Directory System (**IRDS**) and has been ranked as the **top methodology** for database design.

His original ER model paper is **one of the most cited papers** in computer software and **one of 38 most influential papers** in Computer Science. The ER model is a fundamental topic in the **ACM/IEEE recommended curriculum** on computer science and information systems and serves as the foundation of the recent work on **Object-Oriented (OO) analysis and design methodologies** and **Semantic Web**. It is almost a certainty today to see at least one chapter in ER modeling when you open a textbook on information system design or databases. It is also a common practice that most major corporations maintain many wall-to-wall ER diagrams to represent their data models from project data models to enterprise data models.

Besides the ER model, he has made contributions on computer performance evaluation, office automation, and recently on XML and cyber security. He is an Invited Expert in **XML** Schema and XLink working groups of World Wide Web Consortium (W3C).

He is a member of the Advisory Committee of the National Science Foundation (**NSF**)/**Computer and Information Science and Engineering (CISE)** and the **Air Force Scientific Advisory Board**. He has served as a consultant to many corporations and government agencies. He was also a member of the **Airlie Software Council**, a group of software gurus and high-level executives providing advice to large-scale DoD software projects.

Dr. Chen has received many awards, including the Association for Computing Machinery (ACM)/American Association for Artificial Intelligence (AAAI) Allen Newell Award, Institute of Electrical and Electronic Engineers (IEEE) Harry Goode Award, DAMA International Achievement Award, Stevens Award in Software Method Innovation, and Pan Wen-Yuen Outstanding Research Award. He was also inducted into the "Data Management Hall of Fame." He was recognized as one of the 16 software pioneers in a book entitled *Software Pioneers* (Verlag-Springer, 2002). He is a Fellow of IEEE, ACM, and AAAS. He has served as a keynote speaker in approximately 30 international conferences. He has been listed in *Who's Who in America* and *Who's Who in the World* for more than 15 years. He is also listed in several major online dictionaries. More information about him can be found at [www.csc.lsu.edu/~chen](http://www.csc.lsu.edu/~chen).



## **APPENDIX C**

### **ABSTRACTS AND BIOGRAPHIES**

The abstracts and biographies are arranged in alphabetical order by the speaker's last name.

# **Superimposed Tools for Active Arrangement and Elaboration of Resources to Support and Document Learning**

Lois Delcambre, Professor, Computer Science Department, Portland State University

**NSF Award Number 0511050, Lois Delcambre, David Maier (Portland State University); Edward Fox (Va. Tech University; and Lillian Cassel (Villanova University),**

## **Abstract**

Students engaged in studying or scholarly research often scan, review, select, annotate, group, and link bits of information about the subject from a range of source materials. More broadly, a number of analysis and decision support tasks require a similar consideration, selection, and processing of bits of information from a broad range of materials. As an example, an intelligence analyst may piece together bits of evidence that support a particular theory from a number of available information sources. Or a technical manager trying to make decisions may use selected information from various information sources as they try to figure out the current status of their projects and consider “what if” scenarios.

We have been developing the notion of superimposed information for about a decade to support the creation of superimposed information artifacts that select, organize, and elaborate bits of information from a broad range of base information sources, managed by various kinds of base applications. The key features of superimposed information and their associated superimposed applications include:

- Marks. Marks are encapsulated addresses that allow superimposed information to reference bits of information in base sources.
- Heterogeneous base information types. We have implemented marks for a broad range of base information types including: Microsoft® Word, PowerPoint®, and Excel®; Adobe Acrobat®; HTML; XML; plus several video and audio formats, so far.
- Heterogeneous superimposed models. Our superimposed tools have used several different models to structure the superimposed information including a simple nested structure of bundles/groups that can contain marks and an Entity-Relationship model over a set of Acrobat.pdf documents to support browsing and querying.

In one of our current projects we have been exploring the use of superimposed tools for education. We are also exploring whether a superimposed Strand Map model (i.e., a directed graph of learning objectives) can be used to organize lecture and course materials.

In this talk we will consider whether superimposed tools can support active learning in a broad range of environments and also consider whether a Strand Map can provide a useful organizing framework for active learning.

## **Lois Delcambre**

Lois Delcambre is a Professor of Computer Science at Portland State University (PSU). She works in the database field of computer science with a particular interest in database data models as well as other models for structured information, including thesaurus models, knowledge representation models, semi-structured models such as XML and RDF, and ontology models. She is the principal investigator for an NSF-funded project, with David Maier (PSU), Edward Fox (Virginia Tech), and Lillian Cassel (Villanova), that is investigating the use of superimposed tools in education. She is also the principal investigator for an NSF-funded Digital Government project seeking to improve indexing and retrieval performance in domain-specific digital libraries. This project is working in partnership with the health portal for the Healthcare Ministry in Denmark and with the natural resource managers in the U.S., particularly the USDA Forest Service. She and her colleague, David Maier, have just received a new NSF award that will extend the capabilities of superimposed information.

Dr. Delcambre received her Ph.D. in Computer Science from the University of Louisiana, Lafayette (formerly the University of Southwestern Louisiana) in 1982, her M.S. in Mathematics from Clemson University in 1974, and her B.S. in Mathematics with a minor in Computer Science from the University of Louisiana, Lafayette, in 1972. From 1974 to 1979, she was a Systems Design and Software Development Manager at the Division of Information Systems Development at Clemson University.

# **Approaches for Active Conceptual Modeling of Learning**

**Hannu Kangassalo**

University of Tampere, Department of Computer and Information Sciences

P.O.Box 607, FIN-33014 University of Tampere, Finland

E-mail: [hk@cs.uta.fi](mailto:hk@cs.uta.fi)

## **Abstract**

Information modelling is applied in many branches of research and practical work and it can be performed by using different approaches, on several levels, on several perspectives, and in several ways. In this work we regard it as a dynamic collection of processes, in which its content develops from physical processes to abstract knowledge structures. We study that collection first on several levels of abstraction of human cognition and knowledge, then we concentrate on special level of conceptual modeling which has become important in many branches of science and technology, including educational sciences, education technology and learning. Conceptual modelling is regarded as a process of 1) creating, recognition, or finding relevant concepts and conceptual models which describe the Universe of Discourse (UoD) of the information system (IS), and 2) constructing or selecting and representing the relevant conceptual content of information to be contained in the IS, based on this UoD. This characterisation includes active conceptual modelling with construction of new concepts, too. We study conceptual modelling and construction of concepts, conceptual models, and features of factual knowledge, as well as processes in which new information from the UoD may enter the IS, and some important aspects of epistemic information. Most methods developed so far emphasise set theoretical, extensional approach (e.g., ER approach), but other approaches exist, too. Then we analyse some epistemological theories and learning methods, which can be used for collecting information from the UoD, from different points of view. Finally we study some methods for collecting information from various sources in the UoD and accumulating it as possibly actual instances of various types of pre-defined or potential concepts. To some extent, new concepts may be constructed which fit to this collected information. These instances may be cases of sudden events or processes. We try to show some examples and discuss about possibilities of developing an automatic conceptual modelling mechanism.

## Curriculum vitae of Hannu Kangassalo (short version)

### Hannu Kangassalo

University of Tampere  
FIN 33014 University of Tampere  
Finland

Phone: +358-3-3551 6778 (office)  
+358-3-3681 636 (home)  
E-mail: hk@cs.uta.fi  
Fax: +358-3-3551 6070 (office)

- |  |                         |
|--|-------------------------|
| 1. Matriculation examination, the Lyceum of Seinäjoki, Finland | 1965-05-31              |
| 2. Military service, Second lieutenant (09.09.1966)            | 1965-10-15...1966-09-09 |

#### Work at the University of Tampere

- |   |                         |
|---|-------------------------|
| 1. Work at the University of Tampere starts               | 1969-01-01...1969-07-31 |
| 2. Lectured courses on Systems Thinking                   | Fall 1970, 1971, 1972   |
| 3. Assistant in Computer Science (acting)                 | 1970-09-01...1970-12-31 |
| 4. Assistant professor (acting)                           | 1971-01-01...1974-07-31 |
| 5. Associate professor (acting)                           | 1974-08-31...1975-07-31 |
| 6. Assistant, and Research assistant (Academy of Finland) | 1975-08-01...1980-07-31 |
| 7. Assistant professor                                    | 1980-08-01...1984-07-31 |
| 8. Professor (acting)                                     | 1984-08-01...1990-07-31 |
| 9. Assistant professor                                    | 1990-08-01...1992-07-31 |
| on leave for visit in <b>The University of Tokyo</b>      | 1990-09-01...1991-02-28 |
| on sick leave   | 1991-10-06...1992-06-30 |
| 10. Associate professor                                   | 1992-08-01...1998-07-31 |
| 11. Professor (acting)                                    | 1995-01-01...1997-07-31 |
| 12. Professor (Information systems and data structures)   | 1998-08-01...           |

**Work at other Universities: University of Tokyo**, Invited visiting full professor,  
Research Center for Advanced Science and Technology, 1990-08-21...1991-02-26

#### Other full time work, Consulting and teaching in companies and institutions:

- |  |                         |
|--|-------------------------|
| - Neste Oy, Oil refin. comp., Comp. Centre, internship, 13,5 months                    | 1967-06-01...1970-08-25 |
| - Consulting Systems Designer at NESTE, (2880 hours)                                   | 1969-01-01...1973-02-16 |
| - Conceptual modeling at KOP (Bank, 300 hours)   | 1982...1984             |
| - Conceptual modeling, POHJOLA (Insurance comp., 1000 hours)                           | 1980...1983             |
| - Conceptual modeling and teaching at OKO, (Bank, 200 hours)                           |                         |
| - ADP-institute (ATK-instituutti), Lectures on Information systems design, 1972 - 1976 |                         |
| - ADP-institute, Lectures on Data Base Design, 1978...1982 (10 times)                  |                         |

**Research interests:** Information systems design methodologies, especially conceptual modelling for information systems and data base design, data base design tools, conceptual modelling approaches – especially the intensional approach, conceptual schema languages, ontologies, fundamentals of conceptual modelling.

#### Scientific and professional articles: 75

**Reviewer** of many journals and other publications.

**Conference Chairman:** The 20th International Conference on **Conceptual Modeling - ER'02**.

Tampere, Finland. 7 - 11 October, 2002.

**Program Committee chairman** or co-chairman in 20 international conferences or seminars.

**Member** of 70 **program committees** of international conferences.

**Member of IFIP TC8 WG8.1** (Design and Evaluation of Information Systems) The scope of the Working Group is the development of approaches for the analysis, design, specification and evaluation of computer-assisted information systems. 1982-05-16.....

– Chairman of the IFIP TC 8 WG 8.1 1998-06-09...2003-12-31

**Member of ISO/TC97/SC5/WG3** (Data Base Management Systems). The task assigned was to study and analyse possibilities for developing standards for conceptual schema languages. The group published a report 'Concepts and Terminology for the Conceptual Schema and the Information Base' ed. by J. J. van Griethuysen, 1982.

Pirkkala, 2006-04-24 Hannu Kangassalo

# **Schema Changes and Historical Information in Conceptual Models of Learning**

**Luqi**

**Doug Lange**

Computer Science

Naval Postgraduate School

## **Abstract**

State changes and historical information have not been emphasized in traditional approaches to conceptual modeling such as the Entity-Relationship approach. However, these aspects have been modeled and studied in other contexts, such as software maintenance, version control, software transformations, etc. This paper reviews some relevant previous results, shows how they have been used to simplify conceptual models to help people make sense out of complex changing situations, and suggests some connections to conceptual models of machine learning.



## **Doug Lange**

### **(Presenter)**

Doug Lange, Deputy for Command and Control Science and Technology at SSC San Diego, has worked in research and development of command and control capabilities for 22 years. Current research is through the Personalized Assistant that Learns (PAL) program sponsored by DARPA IPTO). Previous R&D projects have included the development of intelligence analysis tools and medical information systems, and developing the integration methods and tools for the DoD's Global Command and Control System (GCCS). He has participated in DoD panels including chairing a panel on decision making technologies for DDR&E), producing the DoD vision for research in this area. Doug has also served as the C3I Consultant to the Commander Seventh Fleet. He received an M.S. degree in Software Engineering from the Naval Postgraduate School in 1996 and a B.S. degree in Computer Science from the University of California at Davis in 1983. He is currently a Ph.D. candidate at the Naval Postgraduate School. His dissertation subject is the evaluation of learning systems. He has published in the areas of AI, hypermedia, and software standards. Doug is a member of IEEE, ACM, and AAAI.

## **Luqi**

Dr. Luqi, IEEE Fellow, professor of Computer Science at the Naval Postgraduate School, has worked on software engineering and artificial intelligence for 30 years, including topics on system modeling, decision support, knowledge representation and normalization, reliable system modification, computer-aided prototyping for real-time and embedded systems, project and system risk assessment, and control systems engineering using requirements specification languages and software architectures. Since her NSF Presidential Young Investigator Award and an IEEE Technical Achievement Award, she founded the Software Engineering Program and Software Engineering Center at the NPS, and has successfully completed hundreds of projects and supervised hundreds of graduate students, including dozens of PhDs. She served as Associate Chair of Computer Science and Director of the Software Engineering Automation Center at the U.S. Naval Postgraduate School. She also served on many editorial boards, including *IEEE Software*, *IEEE Expert and Intelligent Systems*, and *IEEE Transactions on Software Engineering*, and chaired or served on a hundred program committees of conferences and workshops. She was the advisor for many outstanding individuals, including Dr. C. Williamson, White House Policy Analyst; CAPT W. Roof and CAPT P. Young, U.S. Navy; Dr. K. Greaney, Dr. G. Jacoby, Dr. J. Puett, and Dr. M. Murrah, U.S. Army; Dr. D. Nguyen and Dr. R. Steigerwald, U.S. Air Force; and Dr. Michael DaBose, Manager, Technology & Research, Lockheed Martin.

## **Formal Foundations of Conceptual Modeling For Learning from Surprises**

**Stephen W. Liddle, PhD**

Director, Kevin and Debra Rollins Center for eBusiness

Associate Professor, Information Systems Department

Grant and David Fellow

Marriott School of Management

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### **Abstract**

Unexpected events that make a large impact on society occur relatively often. The ability to predict these surprises in advance would be valuable in preserving life, protecting property, and improving quality of life. Predictive power comes from understanding a system's current state, its recent evolution, and its likely or possible future states. The conceptual modeling community has developed sound theory and practices for conceptual modeling that, if properly applied, could help analysts model and predict more accurately. Network theory is valuable for understanding relationships between actors, but it can be improved if we use the ideas developed by the conceptual modeling community. Specifically, we need to associate more semantics with the links, and we need fully reified high-level objects and relationships that have a clear, formal underlying semantics that follows a natural, ontological approach. These concepts already exist, and the theory is well developed; what remains is to link them with the ideas needed to predict system evolution, thus enabling risk assessment and response planning.

## Stephen W. Liddle

Dr. Stephen W. Liddle is currently Director of the Kevin and Debra Rollins Center for eBusiness at Brigham Young University and Associate Professor of Information Systems at the Marriott School of Management, where he holds the Grant and David Fellowship. Dr. Liddle teaches information architecture, web development, and other topics related to the practical application of computer systems, conceptual modeling, and e-business. Liddle has been a member of BYU's business school faculty since 1995, when he received his PhD in Computer Science from BYU. His dissertation dealt with the topic of executable conceptual models, laying some of the groundwork for current efforts in model-driven development and model-driven architecture. Liddle has been active in the conceptual modeling community since the early 1990's, and he currently serves as a member of the steering committee for the International Conference on Conceptual Modeling (the ER Conference). Liddle's research interests include conceptual modeling, software engineering environments and tools, data extraction, information retrieval, multiparadigm software development environments and tools, and e-business. He is particularly interested in applications of conceptual modeling, such as the use of ontologies in data extraction. His work has appeared in journals such as *Data and Knowledge Engineering* and the *Annals of Operations Research*, and in respected conferences such as the ER Conference and the Conference on Information and Knowledge Management, among others. Besides authoring or co-authoring more than 30 refereed academic papers, Liddle is editor of numerous conference and workshop proceedings, and is co-author of the book *E-Business: Principles and Strategies for Accountants*. In addition to co-chairing the ER2003 Program Committee, Liddle has organized or helped organize numerous conferences and workshops, generally in the conceptual modeling space. Liddle currently serves as a member of the Board of Trustees for the Utah Technology Council, and is a member of the Scientific Advisory Board for CARE Technologies, a company in Spain that develops model-compilation software. Liddle has consulted for such companies as Intel®, Zion's Bank, Ray Quinney and Nebeker law firm, Faneuil Research Group Whitewater, and Technology Partners. Liddle has been a prolific software developer since age 14, so he is fluent in many different programming languages. A true "propeller head," he often claims there is nothing he enjoys more than a good old "coding frenzy."

## **An Active XML Data Model**

**Tok Wang Ling\*** and **Gillian Dobbie\*\***

\* School of Computing, National University of Singapore,  
lingtw@comp.nus.edu.sg,  
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\*\* Department of Computer Science, University of Auckland,  
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WWW home page: <http://www.cs.auckland.ac.nz/~gill/>

### **Abstract**

Traditionally, relational database systems have been viewed as repositories that store the information required by an application. Active database systems are extended relational database systems that support active rules for the detection of events occurring in the database and the triggering of actions based on the events. XML is fast emerging as the dominant standard for data representation and exchange on the Web. An active XML system would be very useful in handling similar applications to those handled by active relational database systems. In this paper, we present an active XML data model that represents deductive rules, integrity constraints, and trigger rules based on ORA-SS diagrams and XTree. ORA-SS is a modeling notation for semistructured data and XTree is a declarative query language.

## **Tok Wang LING**

### **(Presenter)**

Dr. Tok Wang LING is a Professor of Department of Computer Science, School of Computing at the National University of Singapore, Singapore.

His research interests include data modeling, Entity-Relationship approach, object-oriented data model, normalization theory, logic and database, integrity constraint checking, semistructured data model, and data warehousing. He has published more than 150 international journal/conference papers and chapters in books, and co-authored a book, mainly in data modeling. He also co-edited 12 conference and workshop proceedings.

He organized and served as program committee co-chair of DASFAA'95, DOOD 1995, ER'98, WISE 2002, and ER 2003. He organized and served/serves as conference co-chair of Human.Society@Internet conference (HSI) in 2001, 2003, and 2005, WAIM 2004, ER 2004, DASFAA, and SIGMOD 2007. He was the Honorary Conference Chair of DASFAA 2006. He serves/served on the program committees of more than 100 international database conferences since 1985.

He is the Advisor of the steering committee of International Conference on Database Systems for Advanced Applications (DASFAA), a member of the steering committee of International Conference on Conceptual Modeling (ER) and the International Conference on Human.Society@Internet (HSI). He was chair and vice chair of the steering committee of ER conference and DASFAA conference, and was a member of the steering committee of DOOD.

He is an editor of the journal Data & Knowledge Engineering, International Journal of Cooperative Information Systems, Journal of Database Management, Journal of Data Semantics, and World Wide Web: Internet, and Web Information Systems.

## **Gillian Dobbie**

Dr. Gillian DOBBIE is currently an Associate Professor in the Department of Computer Science at the University of Auckland, New Zealand, and Director of the Software Engineering Programme.

She received a Ph.D. from the University of Melbourne, an M.Tech.(Hons) and B.Tech.(Hons) in Computer Science from Massey University. She has lectured at Massey University, the University of Melbourne, and Victoria University of Wellington, and held visiting research positions at Griffith University and the National University of Singapore.

Her research interests include formal foundations for databases, object-oriented databases, semistructured databases, logic databases, data warehousing, data mining, access control, e-commerce and data modeling. She has published 40 international refereed journal and conference papers. She is programme chair of ADC 2005 and 2006. She has served on programme committees for many international conferences including DOOD97, ADC98, DaWaK 2001, WISE2002, and ACE2003, ER2006 and has refereed papers for international journals such as *IEEE Transactions on Knowledge and Engineering, Theory and Practice of Logic Programming Journal*, and *VLDB Journal*.

# **The Event Construct in Active Information Systems**

**Salvatore T. March**  
Vanderbilt University

**Gove N. Allen**  
Tulane University

## **Abstract**

Organizations and the information systems that support them are artificial and intentionally designed artifacts. Policies and procedures created by an organization define how specific events affect the states of things about which the organization is concerned. Active information systems are designed to participate in the operation and management of organizational processes. They calculate and ascribe state to material and artificial things according to rules designed by the organization and activated when identified events occur. The ontological definition of an event as a state-transition proscribes the representation of events as entities. The resultant conceptualization of an information system as a state-tracking mechanism obscures the critical role that events play in active information systems. Effective analysis and design of such systems requires a more substantive ontological definition of an event as an entity having both identity and properties. Included in an event's properties are the rules that govern state transitions caused by the event. The resultant conceptualization of an information system is an event-processing mechanism, actively interpreting and re-interpreting events with respect to extant and posed rules. This ontological definition treats things and events uniformly as entities enabling them to have appropriate representations at the conceptual level. It provides a context in which learning can be represented through the definition, identification, and classification of critical events and the evaluation and evolution of rules governing their effects. Additional research is needed to develop and evaluate conceptual modeling grammars and methods that implement this event conceptualization within an information system development methodology.

## **Salvatore T. March** **(Presenter)**

Salvatore T. March is the David K. Wilson Professor of Management at the Owen Graduate School of Management, Vanderbilt University. His research on the design and evaluation of information systems artifacts has appeared in journals such as *ACM Computing Surveys*, *ACM Transactions on Database Systems*, *Communications of the ACM*, *Decision Sciences Journal*, *Decision Support Systems*, *IEEE Transactions on Knowledge and Data Engineering*, *Information Systems Research*, *Journal of MIS*, *Journal of Database Management*, and *MIS Quarterly*. He has served as the Editor-in-Chief of *ACM Computing Surveys*, as an associate editor for *MIS Quarterly*, and as a senior editor for *Information Systems Research*. He is currently senior editor emeritus for *Information Systems Research* and an associate editor for *Communications of the AIS*, *Decision Sciences Journal*, *Journal of Database Management*, *Information Systems and e-Business Management*, the *International Journal of Intelligent Information Technologies*, and *Information Systems Frontiers*.

## **Gove N. Allen**

Gove N. Allen holds B.S. and M.S. degrees in Accountancy from Brigham Young University. Dr. Allen received his Ph.D. from the University of Minnesota in 2001 and currently serves as an assistant professor of e-business and information systems at Tulane University's A. B. Freeman School of Business. He has consulted on the implementation of database technology for many major corporations including Sony®, AT&T®, Sprint®, Hewlett Packard®, Micron®, Intel®, 3M®, American Express®, and the Kennedy Space Center. More recently, he developed WebSQL.org, a site for teaching database management that allows dynamic execution of Structured Query Language against Oracle® databases through a simple Web interface. His research has appeared in journals such as *MIS Quarterly*, *Journal of Database Management*, and *Information Systems Frontiers*.

# **Modeling and Integration of Active Spatial Data for**

## **Future GIS-based Applications**

**Shamkant B. Navathe<sup>\*</sup> and Liora Sahar<sup>\*\*</sup>**

Georgia Institute of Technology

### **Abstract**

GIS, as a research and applied field, has gone through a substantial evolution over the last two decades. New technologies for acquiring, analyzing, storing and retrieving data introduced constant challenges to designers and application developers. GIS incorporates many different fields and requires knowledgeable, interdisciplinary solutions. It is being used in governmental, environmental, military, real-estate, health and many more applications. Each field faces common tasks of data representation, mining, integration and sharing of information. To cope with that places a severe burden on conceptual modeling. Efficient use of GIS information in an integrated fashion with information from other domains will be at the core of future applications in command and control, homeland security, environmental monitoring and emergency response applications. The future depends upon developing an active and dynamic paradigm for ER and other related models to cater to the needs of GIS applications. This paper attempts to review the progress that has been made in GIS and the current state of this emerging, developing field. Conceptual modeling of geographic data requires representation of the different features as well as their spatial topology which is inherently dynamic and calls for the “active” component in modeling. Features to be modeled might be static or dynamic, distinct or fuzzy, continuous or discrete, and those traits make the representation, integration as well as the querying very complex. This field has yet to meet all the current demands and keeps facing new challenges in above applications as it evolves. The paper will discuss the modeling challenges in this ever-growing active and dynamic environment.

\* College of Computing

\*\* College of Architecture and the Center for GIS



## **Shamkant B. Navathe** **(Presenter)**

Sham Navathe is a professor and the head of the database research group at the College of Computing, Georgia Institute of Technology, Atlanta. He is known for his work on database modeling, database conversion, database design, distributed database allocation, and database integration. He has worked with IBM® and Siemens® in their research divisions and has been a consultant to various companies including Digital Equipment Corporation, CCA, Honeywell®, and Equifax®. He was the General Co-chairman of the 1996 International VLDB (Very Large Data Base) conference in Bombay, India. He was also program co-chair of the ACM SIGMOD) 1985 International Conference and General Co-chair of the IFIP WG) 2.6 Data Semantics Workshop in 1995. He was a member of the VLDB Foundation and has been on the steering committees of several conferences, including COOPIS) and the ER Conceptual Modeling Conference. He has been an associate editor of *ACM Computing Surveys*, and *IEEE Transactions on Knowledge and Data Engineering*. He is on several editorial boards including *Information Systems*, *Information Technology and Management*, *Journal of Data Semantics* and the *World-Wide -Web Journal*. He co-authored the book, *Fundamentals of Database Systems*, with R. Elmasri (Addison Wesley, Edition 5), which is currently the leading database textbook worldwide. He also is an author of the book *Conceptual Design: An Entity Relationship Approach* (Addison Wesley, 1992) with Carlo Batini and Stefano Ceri. His current research interests include human genome data management, microarray data analysis, semantic Web for life sciences, data and text mining, GIS information modeling, mobile databases and synchronization, intelligent information retrieval, and Web-based data integration applications. Navathe holds a Ph.D. from the University of Michigan and has over 150 refereed publications.

## **Liora Sahar**

Liora Sahar is a Ph.D. student in Georgia Institute of Technology in the fields of GIS and Databases. Liora is a Geodetic Engineer, graduate of the Technion—Israel Institute of Technology and majored in remote sensing and photogrammetry. She is a member of ASPRS and has professional experience in project and staff management, digital mapping, photogrammetry, remote sensing, and software development. She is presently a graduate research assistant in the Center for GIS at Georgia Tech, working on an NSF-funded project about earthquake risk assessment. Her previous work dealt with feature extraction from aerial and satellite imagery. Her current research interest is in the fields of the semantic Web and remote sensing.

# Understanding the Semantics of Provenance to Support Active Conceptual Modeling

Sudha Ram

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## Abstract

Provenance refers to the history of data including its origin, key events that occur over the course of its lifecycle, and other traceability-related information associated with its creation, processing, and archiving. It is the background knowledge that enables a piece of data to be interpreted correctly and to support learning. Our research focuses on investigating and understanding data provenance in various domains including homeland security. We believe that tracking provenance, such as the processing and usage history of data, enables users to share, discover, and reuse the data, thus streamlining collaborative activities and reducing the possibility of repeating dead ends, and facilitates learning. It also provides a mechanism to transition from static to active conceptual modeling. The primary goal of our research is to investigate the semantics or meaning of data provenance. We are developing an ontology that represents different elements of provenance and their relationships to each other. We conceptualize provenance as a combination of five interconnected elements including, “when”, “where”, “how”, “who”, and “why”. Each of these elements may be used to track events that occur in specific domains such as homeland security. The element “when” records the event time, and “where” captures the event location. The element “how” documents actions leading up to the event. The completion of one or more actions leads to an occurrence of an event. “Who” refers to people or organizations involved in various events. Finally, the element “why” is defined as the decision rationale of an action. The provenance ontology enables us to create a comprehensive record of provenance in a consistent and structured way. In particular, we examine mechanisms to extend current conceptual models to embed time and space (i.e., when and where) to develop active conceptual models.

## **Sudha Ram (Presenter)**

Sudha Ram is Eller Professor, Management Information Systems in the Eller School of Management at the University of Arizona. She received a B.S. degree in mathematics, physics and chemistry from the University of Madras in 1979, PGDM from the Indian Institute of Management, Calcutta in 1981 and a Ph.D. from the University of Illinois at Urbana-Champaign, in 1985.

Dr. Ram has published articles in such journals as *Communications of the ACM*, *IEEE Expert*, *IEEE Transactions on Knowledge and Data Engineering*, *Information Systems*, *Information Systems Research*, *Management Science*, and *MIS Quarterly*. Dr. Ram's research deals with issues related to Enterprise Data Management. Her research has been funded by organizations such as, IBM®, Intel® Corporation, Raytheon®, the U.S. Army, NIST, NSF, NASA, and Office of Research and Development of the CIA. Specifically, her research deals with interoperability among heterogeneous database systems, semantic modeling, bioinformatics and spatio-temporal semantics, business rules modeling, Web services discovery and selection, and automated software tools for database design. Dr. Ram serves on editorial board for such journals as *Decision Support Systems*, *Information Systems Frontiers*, *Journal of Information Technology and Management*, and as associate editor for *Information Systems Research*, *Journal of Database Management*, and the *Journal of Systems and Software*. She has chaired several workshops and conferences supported by ACM, IEEE, and AIS. She is a cofounder of the Workshop on Information Technology and Systems (WITS) and serves on the steering committee of many workshops and conferences, including the Entity Relationship Conference. Dr. Ram is a member of ACM, IEEE Computer Society, INFORMS, and AIS. She is also the director of the Advanced Database Research Group based at the University of Arizona.

## **Jun Liu**

Jun Liu is a doctoral student in management information systems in the Eller School of Management, University of Arizona. His research interests include data provenance, semantic modeling, business rules management, ontology, intelligent data retrieval, and heterogeneous database integration. He has an M.S. degree in management information systems from the University of Arizona.

# **Adaptive and Context-Aware Reconciliation of Reactive and Pro-Active Behavior in Evolving Systems**

**Peter Scheuermann\* Goce Trajcevski1\*\***

Northwestern Univ., Dept. of EECS, {peters, goce}@eecs.northwestern.edu

## **Abstract**

One distinct characteristic of the context-aware systems is their ability to react and adapt to the evolution of the environment, which is often a result of changes in the values of various (possibly correlated) attributes. Based on these changes, reactive systems typically take corrective actions, e.g., adjusting parameters, in order to maintain the desired specifications of the system's state. Pro-active systems, on the other hand, may change the mode of interaction with the environment as well as the desired goals of the system. In this paper we describe our (ECA)<sup>2</sup> paradigm for reactive behavior with proactive impact and we present our ongoing work and vision for a system that is capable of context-aware adaptation while ensuring the maintenance of a set of desired behavioral policies. Our main focus is on developing a formalism that provides tools for expressing normal, as well as defeasible and/or exceptional specification. However, at the same time, we insist on a sound semantics and the capability of answering hypothetical "what-if" queries. One of our desiderata is to enable an "in-concert" dual interaction, both graphical and one based on a high-level language for describing the activities and their effects. We believe that, along with the capability for hypothetical reasoning, this will provide an important foundation for testing, learning and modifying the systems, both in the development stage, as well as the deployed ones.

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\*\* Research supported by the Northrop Grumman Corp., contract: P.O.8200082518

## **Peter Scheuermann** **(Presenter)**

Peter Scheuermann received his Ph.D. in Computer Science from SUNY at Stony Brook in 1976. He has been with Northwestern University since 1976, where he is currently a Professor of Electrical Engineering and Computer Science. He has held visiting professor positions with the Free University of Amsterdam, the Technical University of Berlin, and the Swiss Federal Institute of Technology, Zurich. During 1997–1998 he served as Program Director for Operating Systems and Compilers in the Computer and Communications Division of the National Science Foundation.

Dr. Scheuermann has served on the editorial board of the *Communications of ACM*, *VLB Journal*, and *IEEE Transactions on Knowledge and Data Engineering*. He served as general chair of the ACM-SIGMOD Conference in 1988, general chair of Foundations of Data Organizations 1993, program co-chair of the Fifth International Conference on Cooperative Information Systems 2000, and more recently, as the general chair of the ER 2003 Conference. He was a member of the ACM-SIGMOD advisory board and prior to this chaired the ACM-SIGMOD awards committee.

His current research interests lie in distributed database systems, mobile database systems, I/O systems, physical database design and performance evaluation, logical database design, data warehousing and data mining. His research has been funded by NSF, NASA, HP, and Northrop Grumman, among others. Peter Scheuermann has published 100 journal and conference papers. He is a Fellow of the IEEE.

## **Goce Trajcevski**

Goce Trajcevski received his Ph.D. in Computer Science from the University of Illinois at Chicago in 2002. He has been with Northwestern University since 2003, as a Post-Doctoral Research Fellow and as a Visiting Research Scholar. Dr. Trajcevski has served as an associate editor of the *ACM DiSC*, reviewer for *ACM Transactions on Database Systems*, *IEEE Transactions on Knowledge and Data Engineering*, and *MANET*. He has been a Program Committee member for ACM-GIS'06, DEBS'06, and STDBM'06, and is local organizing chair of SIGMOD'06. He was given the Best Paper Award in the CoopIS'00 and was nominated for the Best PhD Thesis award at the University of Illinois at Chicago in 2003. His current research interests are in mobile data management and wireless sensor networks. He has published over 25 conference and journal papers and his research is funded by the Northrop Grumman Corporation.

# **A Rule-Based Approach to Entity-Relationship Modeling**

**Il-Yeol Song**

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## **Abstract**

The Entity-Relationship (ER) model is widely used in data modeling and system analysis. Developing a right ER model for a subject domain is still art and science. Discovering a set of domain entity types and non-redundant relationships types is intellectually challenging and time-consuming for novice modelers. This paper presents a rule-based approach to Entity-Relationship modeling. The approach synthesizes several different modeling techniques in the form of rules. The rules integrate the noun analysis method, entity categories, English sentence structures, check lists, and other heuristic rules for modeling. We illustrate our approach using a detailed case study. Our teaching experience shows that our method is effective in developing ER models for many business applications.

## Il-Yeol Song

Il-Yeol Song is a professor in the College of Information Science and Technology at Drexel University, Philadelphia, Pennsylvania. He received M.S. and Ph.D. degrees from the Department of Computer Science, Louisiana State University, in 1984 and 1988, respectively.

His research focuses on practical application of modeling and design theory to real-world problems. His current research areas include database modeling and design, design and performance optimization of data warehouses and the OLAP, database systems for cyber forensics, data modeling and quality in bioinformatics, and object-oriented analysis and design with UML. Dr. Song has won three teaching awards from Drexel University: Exemplary Teaching Award in 1992, Teaching Excellence Award in 2000, and the *Lindback Distinguished Teaching Award* in 2001.

Dr. Song has published more than 130 refereed technical articles in various journals and international conferences. Dr. Song is a co-author of the *ASIS Pratt Severn Excellence in Writing Award* at the ASIS meeting (1997) and the *Best Paper Award* of in the 2004 IEEE Symposium on Computational Intelligence in Bioinformatics and Computational Biology (IEEE CIBCB 2004). He received a *Research Scholar Award* from Drexel University in 1992. He has won 13 awards from the competitions of annual Drexel Sigma Xi Scientific Research or annual Drexel Research Days.

He served or is serving as a program co-chair of the DOLAP Conference 1998, the CIKM 1999, DOLAP 1999, ER 2003, DGOV 2004, and BP-UML 2006. Dr. Song is a steering committee member of CIKM, ER, and DOLAP conferences/workshops. He is a co-editor-in-chief of the *Journal of System and Management Sciences*. He is also an associate editor for the *Journal of Database Management* and *International Journal of E-Business Research*. He was a guest editor for *Journal of Computer and Software Engineering*, *Journal of Computer Science and Information Management*, *Journal of Database Management*, *Data & Knowledge Engineering*, and *Decision Support Systems*. He is a member of ACM, IEEE Computer Society, KSEA, and KOCSEA.

# **Harness Dynamic Human Data and Knowledge:**

## **A Grand Research Challenge**

### **A Position Paper for Motivating Discussions at SSC San Diego Workshop on Active Conceptual Modeling of Learning**

**T. C. Ting, Professor Emeritus**

University of Connecticut

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#### **Abstract**

Drawing from past experience for forecasting the future has long been acknowledged throughout human history, but its potential has yet to be fully recognized. A greater opportunity has been offered by the recent advent in computing, communication and storage technologies. Massive and detailed traces about what happened could be stored and then inferred from them for future actions. Google's enormous success is based mainly on two major factors, the index of entire Internet resources and deriving user's intentions from their search behavior. How to harness dynamic data and knowledge from today's database systems that reflect only the static view of the world, and maintain no trace to the past, is a grand challenge. However, the potential impact would be immense. The dream to have a "database of intentions" that can understand and infer from the past for future directions is not too far from its reality. This position paper initiates a essential step toward this challenge by extending the existing ER Model for modeling dynamics of evolving data with precedent and antecedent relationships that capture temporal and logical orders of inter- and intra-entity behaviors. The characteristics of the changes with respect to when, what, and how would be persistently preserved in the database for learning and inferring from them. The proposed Relationships are presented and illustrated.



## **T. C. Ting**

T. C. Ting is a Professor Emeritus of University of Connecticut. He retired after over 35 years of academic career in 2003. He was on the faculty at Virginia Tech, Georgia Tech, Worcester Tech, and University of Connecticut. He also served as the chair of Information and Computer Sciences Faculty at Georgia and the head of Computer Science Department at Worcester Tech. At University of Connecticut he also served as Associate Dean of Engineering for Research for 10 years, the Head of Compute Science and Engineering Department, and the Director of Precision Manufacturing Institute. During his academic career, he took several visiting positions as program director at the NSF, computer scientist at NBS (now NIST), and visiting professor at University of Hawaii, MIT, and EPFL in Switzerland; and Chief Scientist at Ital Information Systems, S.P.A. in Italy and China B2B.com, Inc. His research interests include areas of data models, database systems, data and information security, and internetworking. He has published over 120 papers and delivered a number of key addresses at national and international conferences.

# **Challenges to Conceptual Modeling**

(Not presented at the workshop)

**Bernhard Thalheim**

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## **Abstract**

Database and information systems technology has substantially changed. Nowadays, content management systems, (information-intensive) web services, collaborating systems, internet databases, OLAP databases, etc. have become buzzwords. At the same time, object-relational technology has gained the maturity for being widely applied. Conceptual modeling has not (yet) covered all these novel topics. It has been concentrated for more than two decades around specification of structures. Meanwhile, functionality, interactivity, and distribution must be included into conceptual modeling of information systems.

The paper develops an approach to conceptual modeling for object-relational, collaborating information systems that support virtual communities of work, integration of information systems, varieties of architecture such as the OLTP-OLAP architecture, varieties of play-out and play-in systems, and data analysis engines. The paper is based on an extended Entity-Relationship model that covers all structuring facilities of object-relational systems. It uses the theory of media types and storyboards for the specification of interactivity and provides a framework for collaboration.

## **Bernhard Thalheim**

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**Full Prof., Christian-Albrechts University Kiel, Department of Computer Science  
Honorary Kolmogorov Professor at Lomonossov University Moskau since 2005**

### **Education, degrees, positions**

- \* Master in Mathematics, Technical University Dresden, 1975
- \* Ph.D., Dr. rer. nat., Lomonossov-University Moskau, 1979
- \* Advanced Ph.D., Dr. rer. nat. habil., Technical University Dresden, 1985
- \* Associated Prof., Technical University Dresden, 1986-89
- \* Full Prof., University Rostock, 1989-93
- \* Visiting Professor, University Kuwait, 1988 - 1990, 2004
- \* Full Prof., Brandenburg Technical University at Cottbus, 1993-2003
  - \* Visiting Professor at several universities in Europe and New Zealand
  - \* Full Prof., Christian-Albrechts University Kiel, since 2003

### **Scientific positions**

- \* Founder and Chair of the conferences "Mathematical Fundamentals of Database Systems (MFDBS)" (later unified with International Conference on Database Theory)  
and "Fundamentals of Information and Knowledge Systems (FoIKS)"
  - \* PC-Chair and Org Chair of 15th International Conference on Conceptual Modeling "ER'96"  
Chair of the ER Steering Committee
  - \* Member in Program Committees of more than 200 conferences, e.g. ACM SIGMOD, ADBC, ADBIS, AI, BTW, CAiSE, CoopIS, EDBT, EJIMK, EMISA, ER, ICDT, INFO, IDBW, MFDBS, NGITS, NLDB, ORM, IEEE International Conference SCCC, TFCS, and WITS
- Published three books and more than 200 papers



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